Section 5. Renewable Energy

Renewable energy sources included in the Combined State Energy Data System (CSEDS) comprise biomass (primarily wood, waste, and ethanol), geothermal, hydroelectric, wind, photovoltaic, and solar thermal energy sources. Renewable energy consumption estimates for all sectors are available for 1960 forward.

Biomass

Different forms of biomass are used by each consuming sector. The residential and commercial sectors burn wood for space heating. The industrial sector's primary biomass source is combustible industrial by-products used for electricity generation and process steam, followed in importance by wood chips. The transportation sector uses ethanol as an additive to motor gasoline. Electric utilities use wood, industrial wood waste and waste gas, and municipal waste as cofiring or primary fuels to produce electricity. Consumption of biomass in all sectors is included in CSEDS for 1960 forward.

Residential Sector

Estimates of wood consumed in the residential sector by State for 1960 through 1979 are from the EIA, *Estimates of U.S. Wood Energy Consumption from 1949 to 1981*. For 1980 forward, State estimates are developed from U.S. totals published in the EIA *Annual Energy Review*, from Census division data collected on the EIA triennial survey, *Residential Energy Consumption Survey (RECS)* for 1981, 1984, 1987, 1990 and 1993, and from U.S. Department of Commerce, Bureau of the Census, annual estimates of number of housing units per State. The 1981 *RECS* provides wood consumption data for the national total and Census Regions. For all other years, *RECS* provides data for the national total and Census Divisions. In addition, the survey sample size of the 1993 *RECS* was large enough to provide data for California, Florida, New York, and Texas. Estimates for the other States in 1993 and for all States in the other years are developed by allocating the U.S. total from the *AER* to the Census Divisions or Regions in proportion to *RECS* data. The regional values are then allocated to the States within the regions in proportion to the Census Bureau housing units per State. Estimates for the years intervening the *RECS* surveys are based on the annual U.S. totals from the *AER* and the State proportions of the preceding available *RECS*, i.e., 1982 and 1983 estimates are based on the State proportions of the 1981 data. On the basis of *RECS* data, the assumption is made that no wood is consumed in the residential sector in Hawaii.

The State data derived above are used in CSEDS as wood consumption in the residential sector, identified in the system as WDRCPZZ. "ZZ" in the following variable names represents the two-letter State code that differs for each State.

WDRCPZZ = wood consumed in the residential sector of each State, in thousand cords.

The State-level data are summed to a U.S. total:

$$WDRCPUS = \Sigma WDRCPZZ$$

The residential sector data in cords are converted to Btu by using the conversion factor of 20 million Btu per cord:

$$WDRCBZZ = WDRCPZZ * 20$$
$$WDRCBUS = \Sigma WDRCBZZ$$

Data Sources

WDRCPZZ — Wood energy consumed by the residential sector by State.

- 1960 through 1979: EIA, *Estimates of U.S. Wood Consumption from 1949 to 1981*, Table A4. Data published in thousand short tons are converted to thousand cords by using the factors of one short ton equals 17.2 million Btu (as published in the footnote of Table A4) and 20 million Btu equal one cord of wood, (as published in EIA, *Household Energy Consumption and Expenditures 1993*, page 314.
- 1980 forward: U.S. totals as published for selected years in the EIA, *Annual Energy Review 1998,* Table 10.3, are converted from trillion Btu to thousand cords (by using the factor of 20 million Btu equal one cord) and allocated to the States as described below. Hawaii residential wood consumption is assumed to be zero for all years.
  - — 1980 through 1983: U.S. Census Region wood consumption in thousand cords from Form EIA-457, "1981 Residential Energy Consumption Survey" is allocated to the States within each Region in proportion to the U.S. Department of Commerce, Bureau of the Census, *American Housing Survey*, "Total Housing Units for States, July 1, 1981." This derived 1981 State series is used to allocate the *AER* annual U.S. total wood consumption to the States for 1980 through 1983.
  - — 1984 through 1986: U.S. Census Division wood consumption in thousand cords from EIA-457, "1984 Residential Energy Consumption Survey" is allocated to the States within each Division in proportion to the U.S. Department of Commerce, Bureau of the Census, *American Housing Survey*, "Total Housing Units for States, July 1, 1984." This derived 1984 State series is used to allocate the *AER* annual U.S. total wood consumption to the States for 1984 through 1986.
  - — 1987 through 1989: U.S. Census Division wood consumption in thousand cords from EIA-457, "1987 Residential Energy Consumption Survey" is allocated to the States within each Division in proportion to the U.S. Department of Commerce, Bureau of the Census, *American Housing Survey*, "Total Housing Units for States, July 1, 1987." This derived 1987 series is used to allocate the *AER* annual U.S. total wood consumption to the States for 1987 through 1989.
  - — 1990 through 1992: U.S. Census Division wood consumption in thousand cords are from Form EIA-457, "1990 Residential Energy Consumption Survey." State-level estimates are available for 1993 for California, Florida, New York, and Texas from the Form EIA-457, "1993 Residential Energy Consumption Survey." Those four States' percentages of their respective Division totals in the 1993 survey are applied to the 1990 Census Division data to derive their 1990 values. Wood consumption by the other States in each Division is estimated by allocating the remaining Division data to the States in proportion to the U.S. Department of Commerce, Bureau of the Census, *American Housing Survey*, "Total Housing Units for States, April 1, 1990." This derived 1990 State series is used to allocate the *AER* annual U.S. total wood consumption to the States for 1990 through 1992.
  - — 1993 forward: Residential wood consumption data for U.S. Census Divisions and for California, Florida, New York, and Texas are from Form EIA-457, "1993 Residential Energy Consumption Survey." Data for the other States in each Division are estimated by allocating the remaining Division data to the States in proportion to the U.S. Department of Commerce, Bureau of the Census, *American Housing Survey*, "Total Housing Units for States, July 1, 1993." This derived 1993 State series is used to allocate the *AER* annual U.S. total wood consumption to the States for 1993 forward.

Commercial Sector

Estimates of wood consumed in the commercial sector by State for 1960 through 1979 are from the EIA, *Estimates of U.S. Wood Energy Consumption from 1949 to 1981*. The data published in thousand short tons are converted to billion Btu by using the conversion factor of one short ton equals 17.2 million Btu. The assumption was made in that report that wood is consumed in the commercial sector in proportion to consumption in the residential sector each year. For 1980 forward national level commercial wood consumption estimates in trillion Btu are from the EIA, *Annual Energy Review*. Using the same methodology as for previous years, the national data are allocated to the States in proportion to residential sector wood use each year.

The data series derived above are used in CSEDS as estimated wood consumption in the commercial sector, WDCCBZZ. "ZZ" in the variable name represents the two-letter State code that differs for each State.

WDCCBUS = wood consumed by the commercial sector in the United States, in billion Btu; and
WDRCPZZ = wood consumed in the residential sector of each State, in thousand cords.

The national wood value is allocated to the States in proportion to residential wood series:

WDCCBZZ = (WDRCPZZ / WDRCPUS) * WDCCBUS

The commercial wood consumption estimates are converted from Btu to cords by using the conversion factor of 20 million Btu per cord:

WDCCPZZ = WDCCBZZ / 20
WDCCPUS = ΣWDCCPZZ

Data Sources

WDCCBUS — Wood consumed by the commercial sector in the United States.

- 1960 through 1979: EIA, *Estimates of U.S. Wood Energy Consumption from 1949 to 1981*, Table A7. Data published in thousand short tons are converted to Btu using the factor of one short ton equals 17.2 million Btu (as published in the footnote of Table A7).
- 1980 forward: EIA, unpublished data shown for selected years in *Annual Energy Review 1998*, Table 10.3.

WDRCPZZ — Wood energy consumed by the residential sector by State.

See sources on page 406.

Industrial Sector

Industrial sector biomass (wood and waste) consumption estimates by State for 1960 through 1979 are from the EIA, *Estimates of U.S. Wood Energy Consumption from 1949 to 1981*. The data, published in thousand short tons, are converted to billion Btu using the factor 1 short ton equals 17.2 million Btu.

Estimates for 1980 forward are based on a national-level data series published for selected years in the EIA, *Annual Energy Review (AER)*; National biomass consumption by type of biomass is collected by Standard Industrial Code (SIC) on the EIA triennial survey Form EIA-846, "Manufacturing Energy Consumption Survey" (MECS) for 1985, 1988, 1991, and 1994. The assumption is made that wood and waste use in the manufacturing sector occurs primarily in the industries included in SIC series 2421 (sawmills and planing mills), 2541 (wood partitions and fixtures), 2621 (paper mills), 2046 (wet corn milling), and 2061 (raw cane sugar). The amount of wood and waste consumed by each of the SIC groups of industries is estimated from the MECS data, and the MECS proportions are used to allocate the U.S. totals from the *AER* to SIC groups for each year. The SIC annual subtotals are allocated to the States using State-level data on the value added in manufacturing processes for each of the SIC series published in the U.S. Department of Commerce, Bureau of the Census, *Census of Manufactures, Industry Series*, for 1982, 1987, and 1992.

For 1989 forward, State-level data on wood and waste consumption by nonutility power producers are available from the Form EIA-867, "Annual Nonutility Power Producer Report" and are also used in the data estimation. These State data in Btu are summed, and the total is subtracted from the *AER* national total. The difference is assumed to be used by the manufacturing sector and is allocated to the States using the methodology described above. The State estimates for manufacturing wood and waste consumption are added to the nonutility State-level data to create State industrial biomass estimates that equal the U.S. totals published in the *AER*.

The State-level estimates derived above in Btu are used in CSEDS as industrial wood and waste consumption (WWICBZZ). "ZZ" in the variable name represents the two-letter State code that differs for each State.

WWICBZZ = wood and waste consumed by the industrial sector of each State, in billion Btu.

The U.S. total is calculated as the sum of the State data:

WWICBUS = ΣWWICBZZ

There are no comparable physical units because industrial biomass is measured in a variety of units (e.g., tons, cubic feet, and kilowatthours).

Data Sources

WWICBZZ — Wood and waste consumed by the industrial sector by State.

- 1960 through 1979: EIA, *Estimates of U.S. Wood Energy Consumption from 1949 to 1981*, Table A10. Data published in thousand short tons are converted to Btu by using the factor of one short ton equals 17.2 million Btu (as published in the footnote of Table A10).
- 1980 forward: EIA estimates developed by using three data sources. U.S. totals for each year are as published for selected years in the EIA, *Annual Energy Review 1998 (AER)*, Table 10.3.
  - — 1980 through 1985: U.S. totals from the *AER* are allocated to Standard Industrial Code (SIC) groups 20, 24, 25, and 26 based on data from the EIA "Manufacturing Energy Consumption Survey 1985 (MECS)," Table 3. These SIC subtotals are allocated to the States using State-level series from the U.S. Department of Commerce, Bureau of the Census, *1982 Census of Manufactures,*Table 2, column titled "Value Added by Manufacture," from the publications for Industry 2061 Raw Cane Sugar, Industry 2046 Wet Corn Milling, Industry 2421 Sawmills and Planing Mills, Industry 2541 Wood Partitions and Fixtures, and Industry 2621 Paper Mills. The State values for each of the four SIC groups are summed to derive State total wood and waste industrial consumption estimates.
  - — 1986 through 1989: U.S. totals from the *AER* are allocated to Standard Industrial Code (SIC) groups 20, 24, 25, and 26 based on data from the EIA "Manufacturing Energy Consumption Survey 1988 (MECS)," Tables 2 and 18. These SIC subtotals are allocated to the States using State-level series from the U.S. Department of Commerce, Bureau of the Census, *1987 Census of Manufactures,*Table 2, column titled "Value Added by Manufacture," from the publications for Industry 2061 Raw Cane Sugar, Industry 2046 Wet Corn Milling, Industry 2421 Sawmills and Planing Mills, Industry 2541 Wood Partitions and Fixtures, and Industry 2621 Paper Mills. The State values for each of the four SIC groups are summed to derive State total wood and waste industrial consumption estimates.
    For 1989 only, State-level data on wood and waste consumption by nonutility power producers are available from the Form EIA-867, "Annual Nonutility Power Producer Report" in billion Btu. These nonutility State data are summed and subtracted from the *AER* U.S. total. The remaining value is assumed to be the manufacturing sector and is allocated to the States using the method above. The State values for each of the four SIC groups and the nonutilities are summed to derive State total wood and waste industrial consumption estimates.
  - — 1990 through 1993: State-level data on wood and waste consumption by nonutility power producers from the Form EIA-867, "Annual Nonutility Power Producer Report" in billion Btu are summed and subtracted from the *AER* U.S. total. The remaining national value is allocated to Standard Industrial Code (SIC) groups 20, 24, 25, and 26 based on unpublished data from the EIA "Manufacturing Energy Consumption Survey 1991 (MECS)." SIC groups 20 and 26 are grouped as "Other" in MECS 1991. The proportions of those two groups in the 1988 and 1994 MECS are averaged and used to estimate the breakout for 1991. These SIC subtotals are allocated to the States using State-level series from the U.S. Department of Commerce, Bureau of the Census, *1992 Census of Manufactures,* Table 2, column titled "Value Added by Manufacture," from the publications for Industry 2061 Raw Cane Sugar, Industry 2046 Wet Corn Milling, Industry 2421 Sawmills and Planing Mills, Industry 2541 Wood Partitions and Fixtures, and Industry 2621 Paper Mills. The State values for each of the four SIC groups and the nonutilities are summed to derive State total wood and waste industrial consumption estimates.
  - — 1994 forward: State-level data on wood and waste consumption by nonutility power producers from the Form EIA-867, "Annual Nonutility Power Producer Report" in billion Btu are summed and subtracted from the *AER* U.S. total. The remaining national value is allocated to Standard Industrial Code (SIC) groups 20, 24, 25, and 26 based on data from the EIA "1994 Manufacturing Energy Consumption Survey (MECS), Table A7." These SIC subtotals are allocated to the States using State-level series from the U.S. Department of Commerce, Bureau of the Census, *1992 Census of Manufactures,* Table 2, column titled "Value Added by Manufacture," from the publications for Industry 2061 Raw Cane Sugar, Industry 2046 Wet Corn Milling, Industry 2421 Sawmills and Planing Mills, Industry 2541 Wood Partitions and Fixtures, and Industry 2621 Paper Mills. The State values for each of the four SIC groups and the nonutilities are summed to

derive State total wood and waste industrial consumption estimates.

Transportation Sector

Biomass is consumed in the transportation sector in the form of ethanol blended into motor gasoline. Ethanol can be derived from sugar cane, sugar beets, corn, sweet sorghum, wheat, and other grains. The U.S. total in CSEDS is fuel ethanol production reported on the "Monthly Oxygenate Telephone Report," Form EIA-819M. A State data series, estimated by the U.S. Department of Transportation, Federal Highway Administration, and published in *Highway Statistics,* represents ethanol consumed in gasohol. Ethanol estimates are kept separately in CSEDS and shown in the *SEDR* tables to illustrate renewable energy use, but ethanol consumption is already accounted for within the motor gasoline data series.

ENTRPZZ = ethanol blended into motor gasoline by State, in thousand gallons; and
ENACPUS = ethanol consumed in the transportation sector in the United States, in thousand gallons.

The U.S. value, ENACPUS, is allocated to the States in proportion the *Highway Statistics* State estimates, ENTRPZZ:

ENTRPUS = ΣENTRPZZ
ENACPZZ = (ENTRPZZ / ENTRPUS) * ENACPUS

Ethanol is converted to equivalent British thermal units (Btu) by using a conversion factor of 76,400 Btu per gallon.

ENACBZZ = ENACPZZ * 0.0764
ENACBUS = ΣENACBZZ

Data Sources

ENACPUS — Ethanol consumed by the transportation sector in the United States.

- 1960 through 1988: No data are available. Values are assumed to be zero.
- 1989 through 1992: EIA, *Annual Energy Review 1998*, Table 10.2. Data in quadrillion Btu are converted to gallons by using the conversion factor of 76,400 Btu per gallon.
- 1993 forward: EIA, *Petroleum Supply Monthly* (January issue of each year), Table D1. Data in thousand barrels are converted to thousand gallons by using the conversion factor of 42 gallons per barrel.

ENTRPZZ — Ethanol blended into motor gasoline by State.

- 1960 through 1988: No data are available. Values are assumed to be zero.
- 1989 through 1992: No data are available. The 1993 data are used for each year.
- 1993 through 1995: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics, Sumary to 1995,* Table MF-233E, column "Total Ethanol Used in Gasohol."
- 1996 forward: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, Table MF-33E, column "Total Ethanol Used in Gasohol."

Electric Utilities

Electric utilities' generation of electricity from wood and waste energy, by State, are available combined from 1960 through 1981 and separately from 1982 forward from the Form EIA-759, "Monthly Power Plant Report." The data identifiers in CSEDS are:

WDEOPZZ = electricity produced from wood energy sources at electric utilities in each State (included in waste energy for 1960 through 1981), in million kilowatthours; and
WSEOPZZ = electricity produced from waste energy sources at electric utilities in each State (includes wood energy for 1960 through 1981), in million kilowatthours.

The U.S. totals are calculated as the sum of the State data, and wood and waste are summed to provide a total (WW) value:

WDEOPUS = ΣWDEOPZZ
WSEOPUS = ΣWSEOPZZ
WWEOPZZ = WDEOPZZ + WSEOPZZ
WWEOPUS = ΣWWEOPZZ

Electricity produced from wood and waste sources is converted into Btu by use of a conversion factor that is the U.S. average heat content of fossil fuels burned at steam-electric power plants, FFEOKUS. The annual values for this factor are shown in Appendix C, Table C1.

WDEOBZZ = WDEOPZZ * FFEOKUS
WDEOBUS = ΣWDEOBZZ

WSEOBZZ = WSEOPZZ * FFEOKUS
WSEOBUS = ΣWSEOBZZ

WWEOBZZ = WDEOBZZ + WSEOBZZ
WWEOBUS = ΣWWEOBZZ

Data Sources

WDEOPZZ — Electricity produced from wood energy sources at electric utilities by State.

- 1960 through 1981: Data included in waste energy sources, see WSEOPZZ.
- 1982 forward: EIA, Form EIA-759, "Monthly Power Plant Report.

WSEOPZZ — Electricity produced from waste energy sources at electric utilities by State.

- 1960 forward: EIA, Form EIA-759, "Monthly Power Plant Report" (includes wood energy sources from 1960 through 1981).

FFEOKUS — Fossil fuel steam-electric power plant conversion factor.

- 1960 through 1991: Estimated by EIA as the weighted annual average heat rate for fossil-fueled steam-electric plants in the United States as published in the EIA, *Electric Plant Cost and Power Production Expenses 1991*, Table 9.
- 1992 forward: Unpublished factors calculated on the basis of data from Form EIA-767.

Totals

State total consumption of biomass is calculated as the sum of the consumption in the residential, commercial, industrial, and transportation sectors as well as consumption at electric utilities. The U.S. total is the sum of the State data:

BMTCBZZ = WDRCBZZ + WDCCBZZ + WWICBZZ + ENACBZZ + WWEOBZZ
BMTCBUS = ΣBMTCBZZ

Geothermal

Geothermal energy used as direct heat or from heat pumps in the residential, commercial, and industrial sectors is included in the Combined State Energy Data System (CSEDS) for 1989 forward. Geothermal energy used to generate electricity by nonutility power producers is also included in CSEDS industrial sector from 1989 forward. CSEDS data on energy input at electric utilities includes geothermal energy for all years, 1960 forward, and includes imports of electricity from Mexico that are generated from geothermal energy for 1989 forward These data series are identified in CSEDS by the following names ("ZZ" in the variable name represents the two-letter State code that differs for each State):

GECCBZZ = direct use of geothermal energy and heat pumps in the commercial sector by State, in billion Btu;
GEEOPZZ = electricity produced from geothermal energy at electric utilities by State, in million kilowatthours;
GEIMPZZ = electricity produced from geothermal energy and imported into the United States by State, in million kilowatthours;
GEINBZZ = direct use of geothermal energy and heat pumps in the industrial sector by State, in billion Btu;
GENGBZZ = electricity produced from geothermal energy by nonutility power producers by State, in billion Btu; and
GERCBZZ = direct use of geothermal energy and heat pumps in the residential sector by State, in billion Btu.

The U.S. totals for the State-level series are calculated by summing the State data:

GECCBUS = ΣGECCBZZ
GEEOPUS = ΣGEEOPZZ
GEIMPUS = ΣGEIMPZZ
GEINBUS = ΣGEINBZZ
GENGBUS = ΣGENGBZZ
GERCBUS = ΣGERCBZZ

Industrial sector use of geothermal energy is the sum of direct use and heat pumps and electricity produced by nonutility power producers:

GEICBZZ = GEINBZZ + GENGBZZ
GEICBUS = ΣGEICBZZ

Electricity imports produced from geothermal energy are added to the electricity produced from geothermal energy at electric utilities to be shown in the "Geothermal Energy" column of the *State Energy Data Report* (*SEDR*) tables titled "Energy Input at Electric Utilities."

GEENPZZ = GEEOPZZ + GEIMPZZ
GEENPUS = ΣGEENPZZ

To convert electricity produced from geothermal energy from kilowatthours into comparable Btu, a U.S. average factor that varies by year is used. The values for the factor, GEEOKUS, are shown in Appendix C, Table C1.

GEEOKUS = factor for converting electricity produced from geothermal energy from kilowatthours to Btu.

The values for each sector within each State are converted to Btu:

GEEOBZZ = GEEOPZZ * GEEOKUS
GEEOBUS = ΣGEEOBZZ
GEIMBZZ = GEIMPZZ * GEEOKUS
GEIMBUS = ΣGEIMBZZ
GEENBZZ = GEEOBZZ + GEIMBZZ
GEENBUS = ΣGEENBZZ

The State totals for geothermal energy are the sum of the residential, commercial, and industrial sectors' use and the electric utilities' geothermal-based generation (including imports). The U.S. total is the sum of the State data.

GETCBZZ = GERCBZZ + GECCBZZ + GEICBZZ + GEENBZZ
GETCBUS = ΣGETCBZZ

Additional Note

Geothermal energy from direct use and heat pumps in the residential, commercial, and industrial sectorss are from the Oregon Institute of Technology Geoheat Center. State data for 1989 1994, and 1998 are from surveys. U.S. totals for intervening years are estimates. The State data for 1989, 1994, and 1998 are used to estimate the State values for intervening years by using the following methodology. States with the same value in two survey years are assigned that value for each intervening year. For States with increases or decreases in the survey data, the difference is allocated evenly over the intervening years. If a State went from zero to a value or from a value to zero, it was given zero in the intervening years. The State data for each intervening year are summed and States with increasing or decreasing values are adjusted until the U.S. total equals the U.S. total estimated by the Oregon Institute of Technology Geoheat Center.

Data Sources

GECCBZZ — Direct use and heat pump geothermal energy in the commercial sector.

- 1989: Lund, John W., Oregon Institute of Technology Geoheat Center, unpublished tables, (Klamath Falls, Oregon: April 1999), based on a survey.
- 1990 through 1993: U.S. totals are estimates from the Oregon Institute of Technology Geoheat Center, unpublished tables. State data for 1989 and 1994 are used to estimate State values for the intervening years. For an the explanation of the estimation methodology, see the note on page 411.
- 1994: Lund, John W., Oregon Institute of Technology Geoheat Center, unpublished tables, (Klamath Falls, Oregon: April 1999), based on a survey.

- 1995 forward: U.S. totals are from the Oregon Institute of Technology Geoheat Center, unpublished tables. State data for 1994 and 1998 are used to estimate State values for the intervening years. For an the explanation of the estimation methodology, see the "Additional Note" above.

GEEOKUS — Factor for converting electricity produced from geothermal energy from physical units to Btu.

- 1960 through 1981: Calculated by EIA by weighting the annual average heat rates of operating geothermal units by the installed nameplate capacities as reported on Federal Power Commission Form 12.
- 1982 forward: Estimated annually by the EIA on the basis of an informal survey of relevant plants.

GEEOPZZ — Electricity produced from geothermal energy at electric utilities by State.

- EIA, Form EIA-759, "Monthly Power Plant Report," and predecessor forms.

GEIMPZZ — Electricity produced from geothermal energy and imported into the United States by State.

- 1960 through 1988: No data available. Values assumed to be zero.
- 1989 forward: EIA estimates based on data from U.S. Department of Energy, Fossil Energy, Form FE-781R, "Annual Report of International Electricity Export/Import Data."

GEINBZZ — Direct use and heat pump geothermal energy in the industrial sector.

- 1989: Lund, John W., Oregon Institute of Technology Geoheat Center, unpublished tables, (Klamath Falls, Oregon: April 1999), based on a survey.
- 1990 through 1993: U.S. totals are estimates from the Oregon Institute of Technology Geoheat Center, unpublished tables. State data for 1989 and 1994 are used to estimate State values for the intervening years. For an the explanation of the estimation methodology, see the note on page 411.
- 1994: Lund, John W., Oregon Institute of Technology Geoheat Center, unpublished tables, (Klamath Falls, Oregon: April 1999), based on a survey.
- 1995 forward: U.S. totals are from the Oregon Institute of Technology Geoheat Center, unpublished tables. State data for 1994 and 1998 are used to estimate State values for the intervening years. For an the explanation of the estimation methodology, see the note on page 411.

GENGBZZ — Electricity produced from geothermal energy by nonutility power producers by State.

- 1960 through 1988: No data available. Values assumed to be zero.
- 1989 forward: EIA estimates based on data collected on Form EIA-867, "Annual Nonutility Power Producers Report."

GERCBZZ — Direct use and heat pump geothermal energy in the residential sector.

- 1989: Lund, John W., Oregon Institute of Technology Geoheat Center, unpublished tables, (Klamath Falls, Oregon: April 1999), based on a survey.
- 1990 through 1993: U.S. totals are estimates from the Oregon Institute of Technology Geoheat Center, unpublished tables. State data for 1989 and 1994 are used to estimate State values for the intervening years. For an the explanation of the estimation methodology, see the note on page 411.
- 1994: Lund, John W., Oregon Institute of Technology Geoheat Center, unpublished tables, (Klamath Falls, Oregon: April 1999), based on a survey.
- 1995 forward: U.S. totals are from the Oregon Institute of Technology Geoheat Center, unpublished tables. State data for 1994 and 1998 are used to estimate State values for the intervening years. For an the explanation of the estimation methodology, see the note on page 411.

Hydroelectric Power

Electricity produced from hydropower in the industrial sector and by electric utilities is included in CSEDS for all years. The industrial sector includes estimates of hydroelectricity generation by industries for their own use for all years, as well as generation by nonutility power producers for sale in 1990 forward as collected on the Form EIA-867, "Annual Nonutility Power Producers Report." Industrial data for 1990 forward are not

available in kilowatthours but are included in CSEDS in equivalent British thermal units (Btu). Data on electric utilities' use of hydropower are collected on the Form EIA-759, "Monthly Power Plant Report," and include two types of hydropower—conventional and pumped storage. Conventional hydroelectric power uses falling water to drive turbines to produce electricity. With pumped storage hydroelectricity, energy is used to pump water into higher storage areas during non-peak hours so that it can be released to drive turbines during times of peak electricity demand. Because pumped storage hydroelectricity uses energy, it is not considered a renewable energy source; however, it is discussed in this chapter with other hydropower.

The hydroelectric data series included in CSEDS are identified by the following names ("ZZ" in the name represents the two-letter State code that differs for each State):

HVEOPZZ = electricity produced by conventional hydroelectric power at electric utilities, in million kilowatthours;
HPEOPZZ = electricity produced by pumped storage hydroelectric power at electric utilities, in million kilowatthours;
HYICPZZ = electricity produced by hydroelectric power at industrial facilities, by State, in million kilowatthours (available for 1960–1988 only);
HYICBZZ = electricity produced by hydroelectric power at industrial facilities, by State, in billion Btu;
HYIMPZZ = electricity produced from hydroelectric power and imported into the United States, by State, in million kilowatthours; and
HYEXPZZ = electricity produced from hydroelectric power and exported from the United States, by State, in million kilowatthours.

The U.S. value for each of the series is the sum of the State data.

Total electricity produced from hydropower at electric utilities is calculated as the sum of conventional and pumped storage hydroelectric power.

HYEOPZZ = HVEOPZZ + HPEOPZZ
HYEOPUS = ΣHYEOPZZ

Hydroelectric-based electricity that is imported and exported across U.S. borders is added to the electric utility hydroelectric generation and shown in the "Hydroelectric Power" column of the *State Energy Data Report (SEDR*) tables titled "Energy Input at Electric Utilities."

HYENPZZ = HYEOPZZ + HYIMPZZ – HYEXPZZ
HYENPUS = ΣHYENPZZ

Additional calculations are made to estimate the renewable portion of hydroelectric power at electric utilities, i.e., excluding hydroelectricity produced from pumped storage:

HVENPZZ = HVEOPZZ + HYIMPZZ – HYEXPZZ
HVENPUS = ΣHVENPZZ

Electricity produced from hydroelectric power is converted from kilowatthours into Btu by using a conversion factor that is the U.S. average heat content of fossil fuels consumed at steam-electric power plants, FFEOKUS. The annual values for this factor are shown in Appendix C, Table C1.

HPEOBZZ = HPEOPZZ * FFEOKUS
HVEOBZZ = HVEOPZZ * FFEOKUS
HYEOBZZ = HPEOBZZ + HVEOBZZ

HYIMBZZ = HYIMPZZ * FFEOKUS
HYEXBZZ = HYEXPZZ * FFEOKUS
HYENBZZ = HYEOBZZ + HYIMBZZ – HYEXBZZ
HVENBZZ = HVEOBZZ + HYIMBZZ – HYEXBZZ

The U.S. value for each of the series is the sum of the State data.

Total hydroelectricity consumption for each State is the sum of the electric utilities generation (plus imports and minus exports) and the industrial sector generation:

HYTCBZZ = HYENBZZ + HYICBZZ
HYTCBUS = ΣHYTCBZZ

Total hydroelectricity consumption for each State in million kilowatthours is available for only 1960 through 1988 to avoid disclosure of company

proprietary data in the later years. The formulas for 1960 through 1988 are:

HYTCPZZ = HYENPZZ + HYICPZZ
HYTCPUS = ΣHYTCPZZ

Data Sources

FFEOKUS — Fossil fuel steam-electric power plant conversion factor.
- 1960 through 1991: Estimated by EIA as the weighted annual average heat rate for fossil-fueled steam-electric plants in the United States as published in the EIA, *Electric Plant Cost and Power Production Expenses 1991*, Table 9.
- 1992 forward: Unpublished factors calculated on the basis of data from Form EIA-767.

HPEOPZZ — Electricity produced from pumped storage hydropower at electric utilities by State.
- 1960 through 1989: Included in conventional hydroelectric power.
- 1990 forward: EIA, Form EIA-759, "Monthly Power Plant Report."

HVEOPZZ — Electricity produced from conventional hydropower at electric utilities (includes pumped storage hydroelectric power through 1989) by State.
- 1960 through 1977: Federal Power Commission, News Release, "Power Production, Fuel Consumption, and Installed Capacity Data."
- 1978 through 1980: EIA, *Energy Data Reports*, "Power Production, Fuel Consumption and Installed Capacity Data."
- 1981 through 1989: EIA, Form EIA-759, "Monthly Power Plant Report," and predecessor forms. Published data rounded to gigawatthours in the following reports:
  - 1981 through 1985: EIA, *Electric Power Annual 1985*, Table 6.
  - 1986 and 1987: EIA, *Electric Power Annual 1987*, Table 18.
  - 1988 and 1989: EIA, *Electric Power Annual 1989*, Table 14.
- 1990 forward: EIA, Form EIA-759, "Monthly Power Plant Report."

HYEXPZZ — Electricity produced from hydroelectric power and exported from the United States by State.
- 1960 through 1988: Assumed to be equal to total electricity exports (ELEXPZZ).
- 1989 forward: EIA estimates based on data from Natural Resources Canada, *Electric Power in Canada 1996,* and National Energy Board of Canada, *Electricity Exports and Imports* (Ottawa, Canada, 1996).

HYICBZZ — Electricity produced from hydropower at industrial facilities by State.
- 1960 through 1988: Calculated by EIA by multiplying the average factor for fossil fuels burned at steam-electric power plants (FFEOKUS) times the data in CSEDS series HYICPZZ.
- 1989 forward: EIA estimates from data collected on Form EIA-867, "Annual Nonutility Power Producers Report."

HYICPZZ — Electricity produced from hydropower at industrial facilities by State (available for 1960 through 1988 only).
- 1960 through 1978: Federal Power Commission, Form 4, "Monthly Power Plant Report."
- 1979 and 1980: EIA estimates based on previous years' data.
- 1981 through 1988: No data available. The 1980 data are repeated for each year.

HYIMPZZ — Electricity produced from hydroelectric power and imported into the United States by State.
- 1960 through 1988: Assumed to be equal to total electricity imports (ELIMPZZ).
- 1989 forward: EIA estimates based on data from Natural Resources Canada, *Electric Power in Canada 1996,* and National Energy Board of Canada, *Electricity Exports and Imports* (Ottawa, Canada, 1996).

Solar

Estimates of solar energy use for the residential and commercial sectors combined and the industrial sector are included in the Combined State Energy Data System (CSEDS) for 1989 forward. Generation of electricity by electric utilities from solar energy sources is included in CSEDS for 1984 forward.

Residential/Commercial Sector

Solar thermal energy use in the residential and commercial sectors combined is estimated by using data on shipments of solar thermal collectors to States, measured in thousand square feet, as collected on the EIA Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey," and predecessor surveys. The data are published for recent years in the EIA, *Renewable Energy Annual*. The assumptions are that: (1) the retirement/replacement period for solar thermal collectors is 20 years and, therefore, the cumulative square footage of solar thermal collectors produced since 1974 are still in use; (2) the daily average energy output of all three categories of solar thermal collectors is 1,500 Btu per square foot; and (3) the average efficiency of the collectors is 50 percent. The data series are identified in CSEDS by the following names ("ZZ" in the variable name represents the two-letter State code that differs for each State):

SOHCBZZ = energy produced by solar thermal energy collectors in the residential and commercial sectors combined, in billion Btu.

The U.S. total is calculated as the sum of the State data:

SOHCBUS = ΣSOHCBZZ

Industrial Sector and Electric Utilities

Estimates of electricity produced from photovoltaic and solar thermal energy sources by nonutility power producers are included in the CSEDS industrial sector for 1989 forward, in Btu, from data collected on the Form EIA-867, "Annual Nonutility Power Producers Report." Electric utilities' generation from solar sources are included for 1984 forward as collected on the Form EIA-759, "Monthly Power Plant Report." The data identifiers are:

SOEOPZZ = electricity produced from photovoltaic and solar thermal energy sources at electric utilities, by State, in million kilowatthours; and

SOICBZZ = electricity produced from photovoltaic and solar thermal energy sources by nonutility power producers, by State, in billion Btu.

U.S. totals for these series are calculated as the sum of the State data:

SOEOPUS = ΣSOEOPZZ
SOICBUS = ΣSOICBZZ

Electricity produced from photovoltaic and solar thermal energy at electric utilities is converted from kilowatthours to Btu by using a conversion factor that is the U.S. average heat content of fossil fuels consumed at steam-electric power plants, FFEOKUS. The annual values for this factor are shown in Appendix C, Table C1.

SOEOBZZ = SOEOPZZ * FFEOKUS
SOEOBUS = ΣSOEOBZZ

Totals

Each State's total use of photovoltaic and solar thermal energy sources is the sum of the sectors' values, and the U.S. total is the sum of the States' totals:

SOTCBZZ = SOHCBZZ + SOICBZZ + SOEOBZZ
SOTCBUS = ΣSOTCBZZ

Data Sources

FFEOKUS — Fossil fuel steam-electric power plant conversion factor.

- 1960 through 1991: Estimated by EIA as the weighted annual average heat rate for fossil-fueled steam-electric plants in the United States as published in the EIA, *Electric Plant Cost and Power Production Expenses 1991*, Table 9.
- 1992 forward: Unpublished factors calculated on the basis of data from Form EIA-767.

SOEOPZZ — Electricity produced from solar thermal energy sources at electric utilities by State.

- 1960 through 1983: No data available. Values are assumed to be zero.
- 1984 forward: EIA, Form EIA-759, "Monthly Power Plant Report."

SOHCBZZ — Electricity produced from solar thermal energy sources in the residential and commercial sectors combined by State.

- 1960 through 1988: Values are assumed to be zero for consistency with other EIA reports.
- 1989 forward: EIA estimates are developed by using the same method as used for the U.S. data published in the EIA, *Renewable Energy Annual 1995*, Table 11. Shipments of solar thermal collectors in the United States, in thousand square feet, for 1974 forward that are collected on the EIA Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey," are accumulated each year on the basis of the assumption that the replacement/retirement period for solar thermal collectors is 20 years. Data for 1974 through 1985 are available for the U.S. total only. U.S. values are allocated to the States by using an allocating series that is the simple average of each State's 1986 and 1987 data. The U.S. data are adjusted to remove Puerto Rico and the Virgin Islands. California data for 1986 forward are reduced by the number of high-temperature solar thermal collectors (used at an electric utility in California).
  - — State data for 1986 through 1992 used in the accumulated data series are published in the EIA, *Solar Collector Manufacturing Activity* for each year. The table numbers are:
    - 1986 through 1988: Table 5.
    - 1989: Table 4.
    - 1990 through 1992: Table 13.

    California data for 1986 through 1992 are reduced by the number of high-temperature solar thermal collectors shown in the EIA, *Renewable Energy Annual 1995*, Table 13.
  - — 1993 and 1994: EIA, *Renewable Energy Annual 1995*, Tables 13 and H3.
  - — 1995: EIA, *Renewable Energy Annual 1996,* Tables F9 and F10.
  - — 1996: EIA, *Renewable Energy Annual 1997,* Tables 16 and 17.
  - — 1997: EIA, *Renewable Energy Annual 1998,* Tables 15 and 19.

SOICBZZ — Electricity produced from solar thermal energy sources in the industrial sector by State.

- 1960 through 1988: No data available. Values are assumed to be zero.
- 1989 forward: EIA estimates based on data collected on Form EIA-867, "Annual Nonutility Power Producers Report."

Wind

Wind energy used to produce electricity by nonutility power producers is included in the CSEDS industrial sector for 1989 forward in Btu from data collected on the Form EIA-867, "Annual Nonutility Power Producers Report." Electricity generation from wind energy by electric utilities is included for 1983 forward as collected on the Form EIA-759, "Monthly Power Plant Report." The data are identified in CSEDS by the following names ("ZZ" in the variable name represents the two-letter State code that differs for each State):

WYEOPZZ = electricity produced from wind energy at electric utilities, by State, in million kilowatthours; and
WYICBZZ = electricity produced from wind energy in the industrial sector, by State, in billion Btu.

The U.S. totals are calculated as the sum of the State data:

WYEOPUS =ΣWYEOPZZ
WYICBUS =ΣWYICBZZ

Electricity produced from wind energy at electric utilities is converted from kilowatthours to Btu by using a conversion factor that is the U.S. average heat content of fossil fuels consumed at steam-electric power plants, FFEOKUS. The annual values for this factor are shown in Appendix C, Table C1.

WYEOBZZ = WYEOPZZ * FFEOKUS
WYEOBUS = ΣWYEOBZZ

The State and U.S. totals for wind energy are calculated:

WYTCBZZ = WYEOBZZ + WYICBZZ
WYTCBUS = ΣWYTCBZZ

Data Sources

FFEOKUS — Fossil fuel steam-electric power plant conversion factor.

- 1960 through 1991: Estimated by EIA as the weighted annual average heat rate for fossil-fueled steam-electric plants in the United States as published in the EIA, *Electric Plant Cost and Power Production Expenses 1991*, Table 9.
- 1992 forward: Unpublished factors calculated on the basis of data from Form EIA-767.

WYEOPZZ — Electricity produced from wind at electric utilities by State.

- 1960 through 1982: No data available. Values are assumed to be zero.
- 1983 forward: EIA, Form EIA-759, "Monthly Power Plant Report."

WYICBZZ — Electricity produced from wind in the industrial sector by State.

- 1960 through 1988: No data available. Values are assumed to be zero.
- 1989 forward: EIA estimates based on data collected on Form EIA-867, "Annual Nonutility Power Producers Report."

Additional Calculations

Additional calculations are made in CSEDS to aggregate some data series to be shown in the tables of this report. Geothermal, wind, photovoltaic, and solar thermal energy sources are combined to be shown in the "Other" column in tables titled "Energy Consumption Estimates by Source" and "Industrial Energy Consumption Estimates." The variables are calculated for each State and the United States in billion Btu as follows:

GOICBZZ = GEICBZZ + SOICBZZ + WYICBZZ
GOICBUS = ΣGOICBZZ

GOTCBZZ = GETCBZZ + SOTCBZZ + WYTCBZZ
GOTCBUS = ΣGOTCBZZ

Wind, photovoltaic, and solar thermal energy sources are combined to be shown in the "Other" column in tables titled "Estimates of Energy Input at Electric Utilities." The variables are calculated for each State and the United States in billion Btu as follows:

WNEOPZZ = WYEOPZZ + SOEOPZZ
WNEOPUS = ΣWNEOPZZ

WNEOBZZ = WYEOBZZ + SOEOBZZ
WNEOBUS = ΣWNEOBZZ

Renewable Energy Total

Renewable energy subtotals for each consuming sector in thousand Btu can be calculated for 1989 forward by using the same formulas for each State and the U.S. totals. Renewable energy subtotals can also be calculated in physical units for the transportation sector (thousand gallons) and electric utilities (million kilowatthours).

RERCB = WDRCB + GERCB + SOHCB

RECCB = WDCCB + GECCB

REICB = HYICB + WWICB + GOICB

REACP = ENACP
REACB = ENACB

REEOP = HVENP + GEENP + WWEOP + WNEOP
REEOB = HVENB + GEENB + WWEOB + WNEOB

RETCB = RERCB + RECCB + REICB + REACB + REEOB